MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

ETM7136 – DIGITAL COMMUNICATION SYSTEMS AND DESIGN

(M.Eng.Tele)

30 May 2019
2.00 p.m. – 5.00 p.m.
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This examination paper consists of **5 printed pages** (including the cover page) with **4 questions only**.

2. **Attempt ALL questions.** All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided. **Show all relevant steps** to obtain maximum marks.

Question 1 [25 marks]

(a) Discuss two advantages and two disadvantages of digital communication systems compared to analog communication systems. [6 marks]

(b) A modem is designed to trasmit and receive data simultaneously (full duplex) for an analog telephone line which has an signal-to-noise (SNR) of 30 dB and passes audio frequencies over the range of 300 Hz to 3,400 Hz.

(i) What is the maximum transmitted data rate if the frequency range of 300 Hz to 1,500 Hz is used for the transmitted signal? [3 marks]

(ii) What is the maximum received data rate if the frequency range of 1,800 Hz to 3,400 Hz is used for the signal being received simultaneously? [3 marks]

(iii) Determine the required minimum SNR (in dB) for error-free transmission if the intended transmitted data rate is 20 kbps for a transmitted signal passing over the frequency range of 300 Hz to 1,800 Hz. [3 marks]

(c) Compute the normalized power for the following waveforms:

(i) $g(t)=5\cos(2\pi t)$ for $-\infty<t<\infty$ [3 marks]

(ii) $h(t)=3\cos(2t)+5\cos(4t)$ for $-\infty<t<\infty$ [3 marks]

(d) Find the Fourier Transform of the following rectangular pulse

$$x(t)=\begin{cases}1 & -\frac{\tau}{2}\le t<\frac{\tau}{2}\\ 0 & \text{otherwise}\end{cases}$$

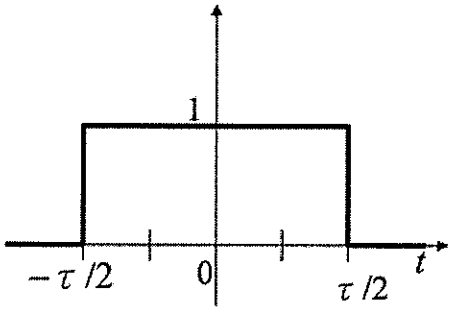

Figure Q1

[4 marks]

Continued...

Question 2 [25 marks]

(a) An analog signal $x(t)=15\cos(3000t+\pi/3)+20\cos(5000t+\pi/2)$ is uniformly sampled for digital transmission.

(i) What is the minimum sampling rate to avoid aliasing? [3 marks]

(ii) What is the maximum allowable time interval between sample values that will ensure perfect signal reproduction? [2 marks]

(iii) How many sample values need to be stored if we want to reproduce 30 minutes of this waveform [2 marks]

(b) Consider an audio signal with spectral components, which are bandlimited to 300-3400 Hz. A sampling rate of 3000 samples/s will be used to generate a pulse code modulation (PCM) signal and the ratio of peak signal power to average quantization noise power at the output is assumed 25 dB.

(i) Determine the minimum number of uniform quantization levels required for this PCM signal. Then, compute the minimum number of bits per sample needed. [3 marks]

(ii) Calculate the system bandwidth required for the detection of the PCM signal. [3 marks]

(iii) Other than quantization noise, discuss one possibility that may produce noise or distortion at the PCM system output. [2 marks]

(c) Briefly explain the working principle of differential PCM (DPCM). [5 marks]

(d) Explain the two types of quantization noises in delta modulation. Suggest a method to reduce these two noises. [5 marks]

Continued...

Question 3 [25 marks]

(a) An audio signal in the range of 300 to 3400 Hz is sampled at 5000 samples/s and transmitted as pulse amplitude modulation (PAM). The samples are first converted to a PCM format and use binary waveforms for transmission.

(i) With a filter roll-off characteristic of $r = 0.5$, determine the minimum system bandwidth required for PAM detection without intersymbol interference (ISI). [2 marks]

(ii) With a filter roll-off characteristic of $r = 0.8$, calculate the minimum system bandwidth required for the detection of binary PCM waveforms if the samples are quantized to 16 levels. [2 marks]

(iii) With a filter roll-off characteristic of $r = 1$, determine the number of quantization levels if the system bandwidth of 30 kHz is used to detect binary PCM waveforms. [3 marks]

(b) 8-ary PAM modulation is used to transmit a series of binary data at the data rate of 12 kbps with a system using a raised cosine roll-off filter characteristic. The system has a frequency response out to 3.2 kHz.

(i) Calculate the symbol rate. [1 mark]

(ii) Determine the roll-off factor of the filter characteristic. [2 marks]

(c) State the main function of matched filter. [2 marks]

(d) A telephone channel passes the frequencies in the band from 400 to 3400 Hz. A modem is designed to transmit at a symbol rate of 2000 symbols/s and at a data rate of 8 kbps. Design an appropriate QAM signal constellation and select appropriate carrier frequency and the roll-off factor of a pulse with a raised cosine spectrum that utilizes the entire frequency band. [7 marks]

(e) Briefly describe coherent and non-coherent demodulations. [6 marks]

Continued...

Question 4 [25 marks]

(a) Define the minimum Hamming distance and explain how this distance affects the error correcting and detecting capabilities. [4 marks]

(b) Consider a Hamming (7,4) code with the generator matrix given by

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

(i) Find the codewords of the codes 0010 and 1010 [4 marks]

(ii) Compute the syndromes for the received vectors 1010010 and 1111000. Determine if any error has occurred. If yes, find the correct codeword(s). [6 marks]

(c) Briefly explain how does Viterbi decoding algorithm work. [4 marks]

(d) Consider a modem operating at 32 kbps that uses trellis coded modulation (TCM).

(i) Find the bandwidth efficiency of the modem if the usable channel bandwidth is 3200 Hz. [1 mark]

(ii) Calculate the required E_b/N_0 (in dB) that will enable a 3200 Hz bandwidth to have a capacity of 32 kbps? [4 marks]

(iii) State one advantage of using TCM. [2 marks]

End of Paper